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Description of two new species of *Amolops* (Anura: Ranidae) from Arunachal Pradesh, Northeast India under the morphological '*Viridimaculatus* species group'

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Abstract

With the descriptions of a large number of *Amolops* species in the last two decades, the historical reports of *Amolops* species from India are in a state of flux, resulting in doubts regarding the specific identities of many species of this genus from the country. Due to their morphological crypticity, species belonging to *Amolops* are most often difficult to identify based only on morphological characters and colour alone. In the recent years, a number of species of this genus have either been described or reported from India, based on both morphological and molecular phylogenetic studies, like *Amolops aniqiaoensis, A. adicola, A. indoburmanensis*, etc. Herein, we are describing two new species of *Amolops,* namely *Amolops chanakya* **sp. nov**. and *Amolops tawang* **sp. nov**. from western Arunachal Pradesh that belong to the morphological '*Viridimaculatus* species group' based on a combination of morphological character data sets, genetic studies, and geographical distribution.

Keywords: *Amolops chanakya* **sp. nov**., *Amolops tawang* **sp. nov**., Cascade Frogs, Chanakya, Cryptic Species, Dirang, Eastern Himalaya, Tawang

Introduction

In India, the cascade dwelling ranid frog genus *Amolops* (Cope, 1856) is found predominantly in the Himalayas and the north-eastern part of the country. Of the 73 species of *Amolops* recognised globally (Frost, 2022), only 14 species are known with certainty from India, of which 11 species were described from the country, namely *Amolops adicola* (Patel, *et al.*, 2021), *A. assamensis* (Sengupta, *et al.,* 2008*), A. chakrataensis* (Ray, 1992), *A. formosus* (Gunther, 1876), *A. gerbillus* (Annandale, 1912), *A. himalayanus* (Boulenger, 1888), *A. jaunsari* (Ray, 1992), *A. kohimaensis* (Biju, *et al.,* 2010), *A. monticola* (Anderson, 1871), *A. nidorbellus* (Biju, *et al.,* 2010) and *A. senchalensis* (Chanda, 1987). The other three *Amolops* species known from India are *A. aniqiaoensis, A. indoburmanensis* and *A. viridimaculatus* sensu stricto (Ao, *et al.,* 2003; Lalronunga, *et al.,* 2020; Saikia, *et al.,* 2022) which were described from the neighbouring countries of China and Myanmar.

Following Jiang, *et al.,* (2021), the species of *Amolops* from India can be divided into three species groups: ***Amolops marmoratus*** **species group** (*A. assamensis, A. gerbillus, A. indoburmanensis, A. jaunsari* and *A. senchalensis*) (henceforth *Marmoratus* group); ***Amolops monticola*** **species group** (*A. aniqiaoensis, A. adicola, A. chakratensis, A. kohimanensis* and *A. monticola* sensu stricto) (henceforth *Monticola* group), and ***Amolops viridimaculatus*** **species group** (*A. formosus, A. himalayanus, A. nidorbellus* and *A. viridimaculatus* sensu stricto) (henceforth *Viridimaculatus* group).

In 2018, two large sized male *Amolops* specimens were collected from West Kameng and Tawang districts of western Arunachal Pradesh in the Eastern Himalaya of India (Figure 1). The absence of dorsolateral folds, presence of distinct vomerine teeth, lack of a distinct cirum-marginal groove in finger I and the absence of tarsal folds and tarsal glands indicate these frogs belong to the morphological *Viridimaculatus* group (Jiang, *et al.,* 2021).

Based on the morphological and molecular phylogenetic studies, and geographical isolation, herein, we describe these two *Amolops* as two new species,

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namely *Amolops chanakya* **sp. nov**. and *Amolops tawang* **sp. nov**. belonging to the '*Viridimaculatus* group'.

Material and Methods

Two specimens of *Amolops* were collected, which were euthanised in 10% alcohol and fixed in 4% formalin overnight and finally transferred into 70% alcohol for preservation. Prior to fixation, liver tissues were extracted for molecular studies, which were preserved in absolute alcohol. Morphometric measurements were taken using a Mitutoyo™ digital calliper (Table 1) following Saikia, *et al.,* (2022), while GPS coordinates were recorded using a GARMIN Oregon 550. The following morphological measurements were taken: AG - axilla to groin distance; EL - eye length, i.e. the horizontal distance between the bony orbital borders of the eye; FL1 - first finger length (tip of finger to proximal palmar tubercle); FL2 - second finger length (tip of finger to proximal palmar tubercle); FLL - forelimb length, measured from the elbow to the base of the outer palmar tubercle; FOL - foot length, measured from the base of the inner metatarsal tubercle to the tip of the fourth toe; FTL - fourth toe length, measured from

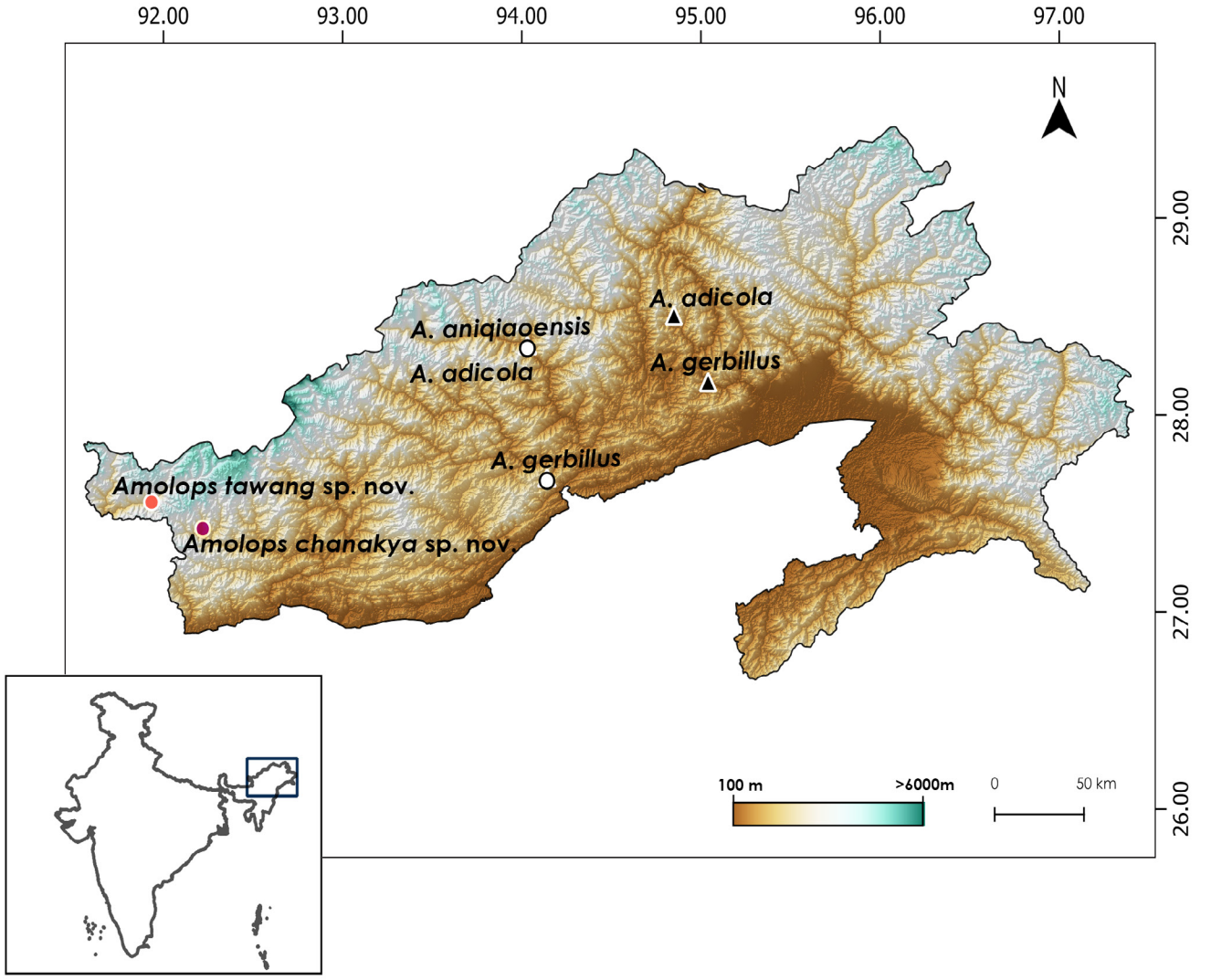

Figure 1. Map of the respective type localities of *Amolops* species described previously from Arunachal Pradesh (black triangles); type localities of species described in this paper (orange and red circles) and other species sampled in our previous studies from Arunachal Pradesh (white circles).

the base of the proximal subarticular tubercle to toe tip; HAL - hand length, measured from the base of the outer palmar tubercle to the tip of the third finger; HL - head length, from the rear of the mandible to the tip of the snout; HW - head width, at the angle of the jaws; IBE - distance between posterior corner of eyes; IFE - distance between anterior corner of eyes; IMT - length of the inner metatarsal tubercle; IN - internarial distance; ITL - inner toe length; IUE - inter upper eyelid width, i.e., the shortest distance between the upper eyelids; MBE - distance from the rear of the mandible to the posterior most orbital border; MFE - distance from the rear of the mandible to the anterior most orbital border; MN - distance from the rear of the mandible to the centre of the nostril; NE—nostril to eye distance; NS—nostril to snout tip distance; ShL/FL - thigh length; SL - snout length, measured from the tip of the snout to the anterior most orbital border; SVL - snout to vent length; Tal - tarsus length; TE - tympanum to posterior corner of eye distance; TFL - third finger length (tip of finger to proximal palmar tubercle); TiL - tibia length; TYD - tympanum diameter; UEW - maximum upper eyelid width; WBS - body width behind shoulders; WFG - body width in front of the groin.

The specimens were deposited and registered in the National Zoological Collections of the North Eastern Regional Centre, Zoological Survey of India, Shillong under the registration numbers: V/A/NERC/ZSI/1771 and 1772.

Molecular study protocols were followed as per Saikia, *et al.,* (2021). PCR amplification of 697 bp of the mitochondrial 16S rRNA gene was performed using 16sar-L and 16Sbr-H primers of Palumbi, *et al.,* (2002) from the genomic DNA of the two amphibian samples mentioned in Appendix 1. Sanger sequencing was outsourced. Low quality base calls were filtered and end-trimmed from trace files of 16S rRNA gene sequence fragments, using SeqTrace (Stucky, 2012). The resultant sequence was checked for corrections in MEGA XI software (Tamura, *et al.,* 2021). Additionally, we have downloaded 212 sequences of *Amolops* available in the GenBank (Appendix 1) and aligned them with our generated sequences in MEGA XI using the MUSCLE algorithm (Edgar, 2004). The sequence names (Table 2) followed as per Saikia, *et al.,* (2022). Maximum likelihood phylogenetic analysis was performed using the GTR+GAMMA+I model in RAxML 2.0.0 (Silvestro and Michalak, 2012) with a thorough 1000 bootstrap replicates. The outgroups were followed after Wu, *et al.,* (2020), and the final consensus tree was visualized in Figure Tree v1.4.0 (Figure 2).

Table 1. Morphometric data (in mm) of the *Amolops* species described in this paper

Species	***A. chanakya* sp. nov.**	***A. tawang* sp. nov.**
Registration No.	V/A/NERC/ ZSI/1771	V/A/NERC/ ZSI/1772
Sex	♂	♂
SVL	76.4	82.5
HW	26.5	28.8
HL	23.6	25.3
IN	8.7	10.7
NE	5.3	5.5
NS	5.6	5.5
MN	18.2	18.3
MFE	13.1	14.8
MBE	7.1	7.9
SL	10.5	11.7
EL	8.2	8.9
IUE	6.2	6.6
UEW	7.1	6.6
IFE	14.8	15.9
IBE	21.4	23.1
TYD	3.4	1.7
TE	3.8	3.5
FLL	15.6	17.1
HAL	29.3	32.5
FL1	11.7	14.7
FL2	19.2	21.4
TFL	29.3	32.5
AGL	29.4	34.6
WBS	20.5	29.0
WFG	15.7	12.4
ShL/ FL	42.8	48.1
TiL	47.6	53.1
Tal	22.8	22.8
FOL	45.2	50.3
FTL	25.4	27.5
ITL	8.2	10.1
IMT	4.6	6.6

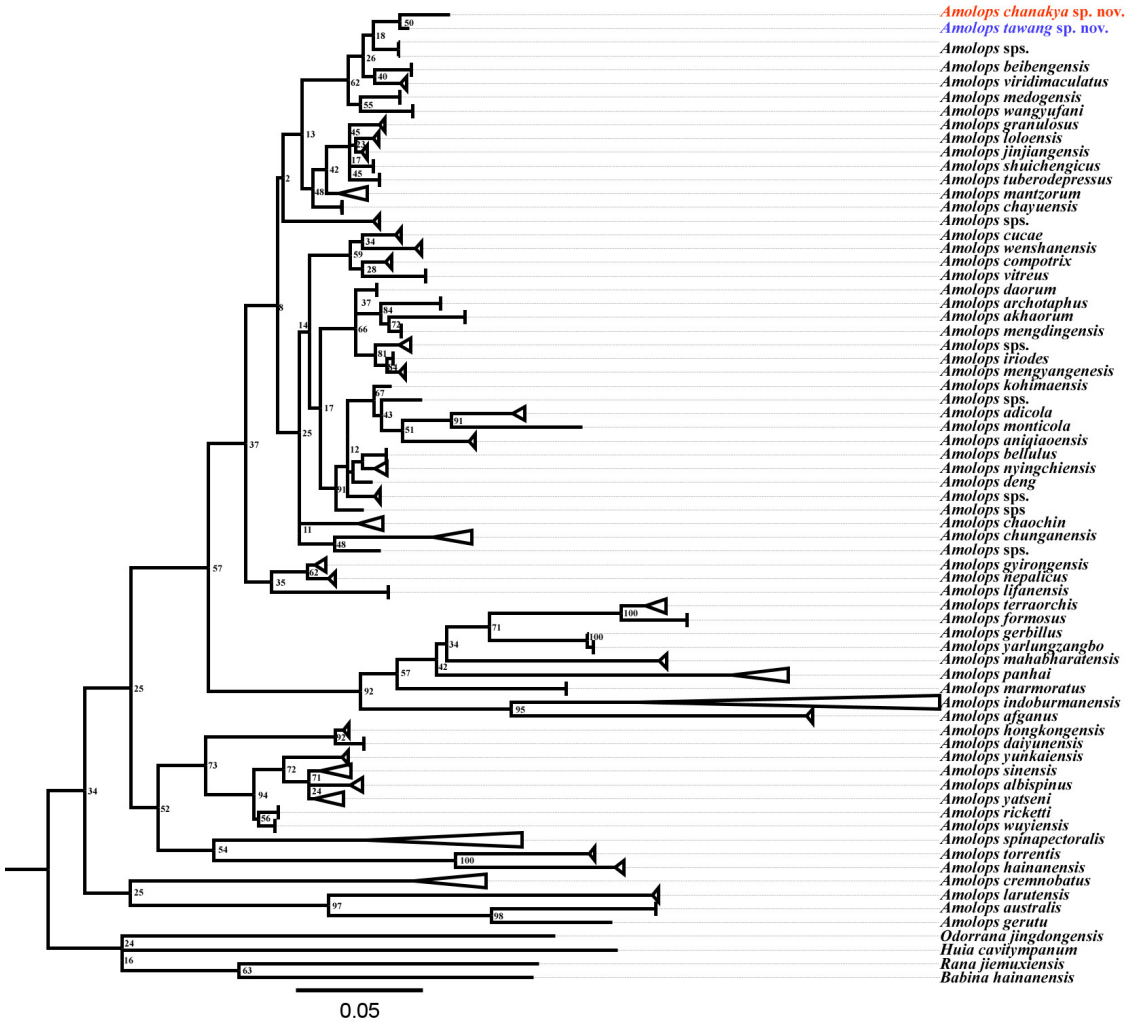

Figure 2. Maximum Likelihood tree for the members of *Amolops* based on 560 bp of mt 16s rRNA.

Results

Phylogenetic Analysis

Both the populations of *Amolops* studied in West Kameng and Tawang, Arunachal Pradesh, were genetically distinct, showing sister relationship among themselves with moderate bootstrap support (Figure 2). Although both the proposed new species described from West Kameng and Tawang are isolated geographically (Figure 1) (allopatric) they show a moderate genetic distance of 1.8% on the 16s rRNA gene. Overall, bootstrap support for most of the species represented on the 16s rRNA gene tree is moderate, suggesting the possibility of poor species representation on the tree suggesting the need for thorough sampling across the entire distributional range of *Amolops* with multigene studies. The two new species described are *Amolops chanakya* **sp. nov.** from West Kameng district and *Amolops tawang* **sp. nov.** from Tawang district of Arunachal Pradesh, India, which are adapted to higher elevations (above 1700 m) hill ranges.

Taxonomy

Class AMPHIBIA Linnaeus, 1758
Order ANURA Dumeril, 1806
Family RANIDAE Batsch, 1796
Genus ***Amolops*** Cope, 1865

Amolops chanakya sp. nov.
(Chanakya's Cascade Frog)
Zoobank ID: urn:lsid:zoobank.org:act:22CC1259-3D8E-47E3-ABE9-E8BCE6B46315

Figure 3. Live colour image of holotype of *Amolops chanakya* **sp. nov.** (Photo: Bikramjit Sinha).

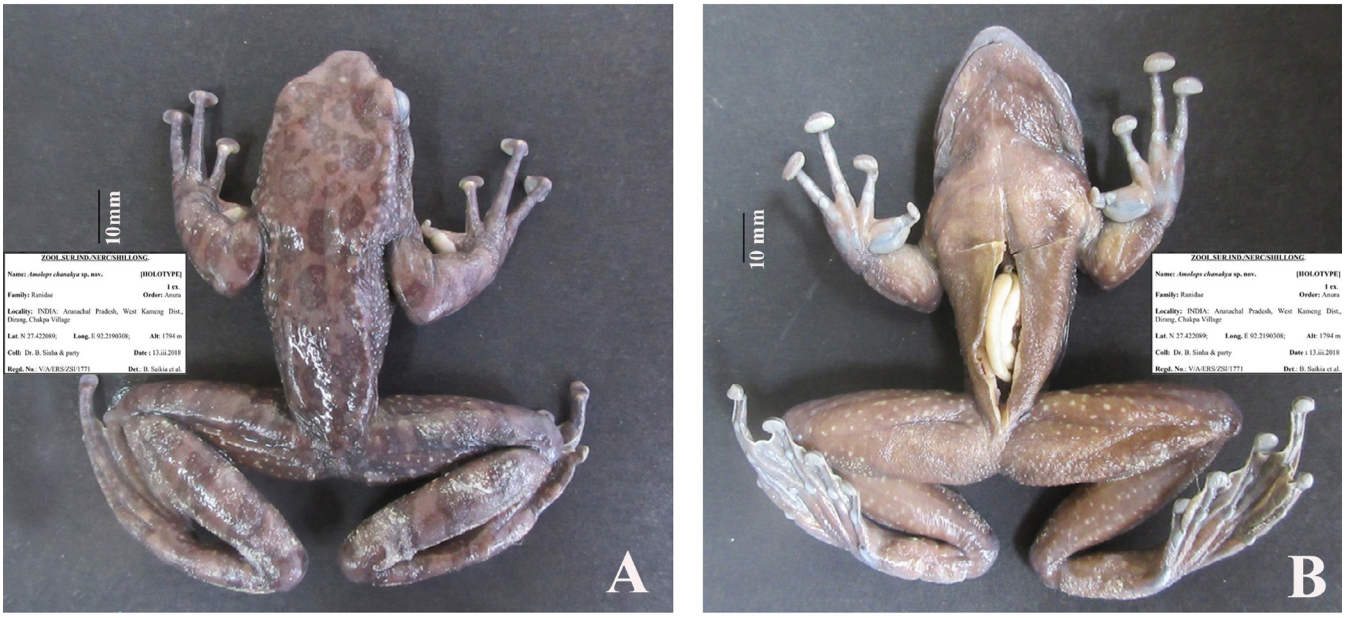
10mm
ZOOL SUR IND./NERC/SHILLONG
Name: Amolops chanakya sp. nov. [HOLOTYPE]
1 ex.
Family: Ranidae Order: Anura
Locality: INDIA: Arunachal Pradesh, West Kameng Dist., Dirang, Chakpa Village
Lat. N 27.422089; Long. E 92.2190308; Alt: 1794 m
Coll: Dr. B. Sinha & party Date : 13.iii.2018
Regd. No. : V/A/ERS/ZSI/1771 Det. : B. Saikia et al.
A
10 mm
ZOOL SUR IND./NERC/SHILLONG
Name: Amolops chanakya sp. nov. [HOLOTYPE]
1 ex.
Family: Ranidae Order: Anura
Locality: INDIA: Arunachal Pradesh, West Kameng Dist., Dirang, Chakpa Village
Lat. N 27.422089; Long. E 92.2190308; Alt: 1794 m
Coll: Dr. B. Sinha & party Date : 13.iii.2018
Regd. No. : V/A/ERS/ZSI/1771 Det. : B. Saikia et al.
B

Figure 4. Holotype image of *Amolops chanakya* **sp. nov.** in preserved condition (**A:** dorsal view; **B:** ventral view).

Holotype: V/A/NERC/ZSI/1771, adult male (Figure 3), collected by Bikramjit Sinha and party on March 13, 2018 from Chakpa Village (N 27.422089; E 92.2190308; alt.: 1794 m), Dirang, West Kameng district, Arunachal Pradesh, India; collected after dusk hours.

Diagnosis: *Amolops chanakya* **sp. nov**. is a member of the morphological *Viridimaculatus* species group isolated in geographical space from its phylogenetic sister species and has a distinct set of morphological characters. The new species can be diagnosed based on the following set of morphological characters: adult male size large (SVL 76.4 mm); head wider than long (HW>HL); snout rounded, longer than eye length (SL>EL); inter-orbital distance less than both upper eyelid width and inter-narial distance (IUE<UEW<IN); tympanum distinct, about 40% of eye length; finger I disk slightly dilated, all disks with circum-marginal grooves, only a hint of groove in finger I; tibia longer than femur and foot (TiL>FOL>ShL), about 2/3rd of SVL; tibio-tarsal articulation reaches up to the nostril; supra-tympanic fold strong; single row of discontinuous roundish tubercles dorso-laterally.

Description of the Holotype: Adult male (SVL 76.4 mm), body robust, head wider than long (HW>HL), flat above; snout rounded, protruding in lateral view, snout longer than the eye diameter (SL>EL); canthus rostralis distinct, loreal region depressed; inter-orbital distance less than both upper eyelid width and inter-narial distance (IUE<UEW<IN); the nostrils laterally placed, slightly nearer to the eyes (NS>NE); pupil horizontal; tympanum distinct, circular and little depressed, separated from the eye by a distance slightly more than its diameter; pineal ocellus visible; a pair of vomerine teeth situated between the choanae; tongue bilobed. Vocal sac externally visible.

Arms strong, forearm length shorter than the hand length; fingers free, tips ending in disk, finger I disk slightly dilated; all disks with circum-marginal grooves, only a hint of groove in finger I, relative length of fingers I<II<IV<III; sub-articular tubercles prominent, circular; prepollex oval.

Hindlimbs long, tibia longer than femur and foot (TiL>FOL>ShL); toes long and thin, tips of all toes dilated into disks with circum-marginal grooves, toes completely webbed; sub-articular tubercles domed shaped; inner metatarsal tubercle oval shaped, outer absent.

Dorsal skin smooth; a single row of discontinuous roundish tubercles dorso-laterally; laterally granular, supra-tympanic fold strong; ventral skin smooth.

The Colouration of the Holotype: (*in life*) Dorsal color dull brick-red, spotted with irregular cocoa-brown spots, these cocoa-brown spots enclosing a number of smaller dull brick-red spots; laterally spotted with neon yellow; ventral color cocoa-brown. Limbs distinctly banded; thighs with alternating dull brick-red and cocoa-brown (speckled with lighter dots) bands, hind limbs with neon yellow spots laterally (Figure 3). *In preservative* same as in live condition, except that all the colours are faded (Figure 4).

Condition of the type: The type is in good condition. Ventral incision was made to extract liver tissue which was used in the molecular study.

Natural history: The holotype was collected after the dusk hours from a small hill stream from Chakpa village.

Distribution: Known from its type locality of Chakpa Village, Dirang Administrative Circle, West Kameng district of Arunachal Pradesh, India.

Comparisons: The new species is compared with the other species of *Viridimaculatus* species group.

From the Indian *Viridimaculatus* species group, *Amolops chanakya* **sp. nov.** differs from *A. formosus* (in parentheses) in having larger male SVL (vs. smaller), nostril nearer to eye (vs. equidistant), tympanum small, distinct (vs. about the size of finger III disk), TiL>ShL (vs. TiL<ShL), inner-metatarsal tubercles distinct (vs. indistinct), outer metatarsal tubercle absent (vs. present), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. bright green with large dark spots); from *A. himalayanus* (in parentheses) in having small tympanum but distinct and depressed (vs. slightly visible), tibia 2/3rd of SVL (vs. almost equal), tibio-tarsal articulation reached up to nostril (vs. beyond the tip of the snout), dorsum dull brick-red, spotted with irregular cocoa-brown spots (vs. olive with darker spots); from *A. nidorbellus* (in parentheses) having distinct pineal ocellus (vs. barely visible), IUE<UEW (vs. IUE>EUW), external vocal sac visible (vs. absent), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. brown with small, irregular cobalt green spots), ventral cocoa-brown (vs. pale brown with scattered small, white spots); from *A. viridimaculatus* sensu stricto (in parentheses) in having wider head (vs. longer), tympanum distinct (vs. indistinct), outer metatarsal tubercle absent (vs. present), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. maroon red with large green blotches); from *A. tawang* **sp. nov.** (in parentheses) in having

smaller male SVL (vs. larger), nostril nearer to the eye (vs. equidistant), IUE<UEW (vs. IUE=UEW), tympanum larger (vs. extremely depressed and small), TYD ≈ TE (vs. TYD= ½TE), external vocal sac distinctly visible (vs. faintly visible), tibio-tarsal articulation reaches up to nostril (vs. snout), dorsum dull brick-red, spotted with irregular cocoa-brown spots (vs. dorsal color olive-green, spotted with large, irregular shaped dark-brown spots), ventral color cocoa-brown (vs. dark, speckled with lighter dots and dashes)

From the *Viridimaculatus* species group found outside India, *Amolops chanakya* **sp. nov.** differs from *A. beibengensis* (in parentheses) in having head wider than long (vs. HL=HW), tibio-tarsal articulation reached up to the nostril (vs. between nose and eye), vocal sac externally visible (vs. absent), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. dorsum brown with green spots); from *A. gyirongensis* (in parentheses) in having larger male SVL >76 mm (vs. <64 mm), vocal sac externally visible (vs. absent); dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. bright green with dark brown irregular large spots); from *A. kaulbacki* (in parentheses) in having larger male SVL > 76 mm (vs. up to 72 mm), IUE<UEW (vs. IUE>UEW), tibio-tarsal articulation reached up to the nostril (vs. beyond snout), vocal sac externally visible (vs. absent), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. green with black spots and marbling); from *A. longimanus* (in parentheses) in not having a distinctive dorsolateral fold (vs. present), absence of parotid-like swelling above tympanum (vs. present); from *A. medogensis* (in parentheses) in having smaller male SVL of 76 mm (vs. 95 mm), vocal sac externally visible (vs. absent), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. olive green with brown markings/dark brown with small yellow-green spots); from *A. pallasitatus* (in parentheses) in having tibio-tarsal articulation reached up to the nostril (vs. posterior eye corner), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. yellow green with irregular dark brown blotches); from *A. splendissimus* (in parentheses) in having a supra-tympanic fold strong (vs. poorly developed), dorsal color

Figure 5. Live colour image of holotype of *Amolops tawang* **sp. nov.** (Photo: Bikramjit Sinha).

dull brick-red, spotted with irregular cocoa-brown spots (vs. black-brown spangled thickly with bright yellow spots); from *A. wangyufani* (in parentheses) in having larger male SVL >76 mm (vs. <70 mm), tibio-tarsal articulation reached up to the nostril (vs. beyond snout), dorsal color dull brick-red, spotted with irregular cocoa-brown spots (vs. brown with sparse green patches).

Etymology: The species epithet is a patronym named after Chanakya (also known as Kautilya or Vishnugupta), a 4th century BCE Indian polymath and administrator famous for Arthashastra, a Sanskrit treatise on economic policies, statecraft and military strategy. The species epithet is treated as a noun in apposition to the generic name.

Suggested Common Name: We suggest **Chanakya's cascade frog** as a common English name and **चाणक्य झरना मेंढक** as a common Hindi name for this species.

Amolops tawang sp. nov.
(Tawang Cascade Frog)
Zoobank ID: urn:lsid:zoobank.org:act:0E8EF24C-3FCD-4D1C-9245-3716E44044C6

Holotype: V/A/NERC/ZSI/1772, adult male (Figure 5), collected by Bikramjit Sinha and party on 08 March, 2018 from the Gomkyaleng village (N 25.925458; E 91.780033; alt.: 1891 m), Jang-Mukto Road, Tawang district, Arunachal Pradesh, India.

Diagnosis: Amolops tawang **sp. nov**. is a member of the morphological *Viridimaculatus* species group isolated in geographical space from its phylogenetic sister species having a distinct morphological set of characters. The new species can be diagnosed based on the following set of morphological characters: adult male size large (SVL 82.5 mm); head wider than long (HW>HL); snout rounded, snout longer than eye length (SL>EL); inter-orbital distance equals the upper eyelid width but smaller than the inter-narial distance (IUE=UEW<IN); tympanum small and extremely depressed, about 20% of eye length; finger I disk slightly dilated, all disks with circum-marginal grooves, but absent in finger I; tibia longer than femur and foot (TiL>ShL), about 2/3rd of SVL; tibio-tarsal articulation reaches up to snout; supra-tympanic fold strong; dorso-lateral skin granular.

Description of the Holotype: Adult male (SVL 82.5 mm), body robust, head wider than long (HW>HL), flat above; snout rounded, protruding in lateral view; snout longer than the eye diameter (SL>EL); canthus rostralis distinct, loreal region depressed; inter-orbital space flat, equals the width of the eyelid, but narrower than the inter-narial distance (IUE=UEW<IN); the nostrils laterally placed, equidistant between snout and eye (NE=NS); pupil horizontal; tympanum small and extremely depressed, separated from the eye by a distance of more than twice its diameter; pineal ocellus visible;

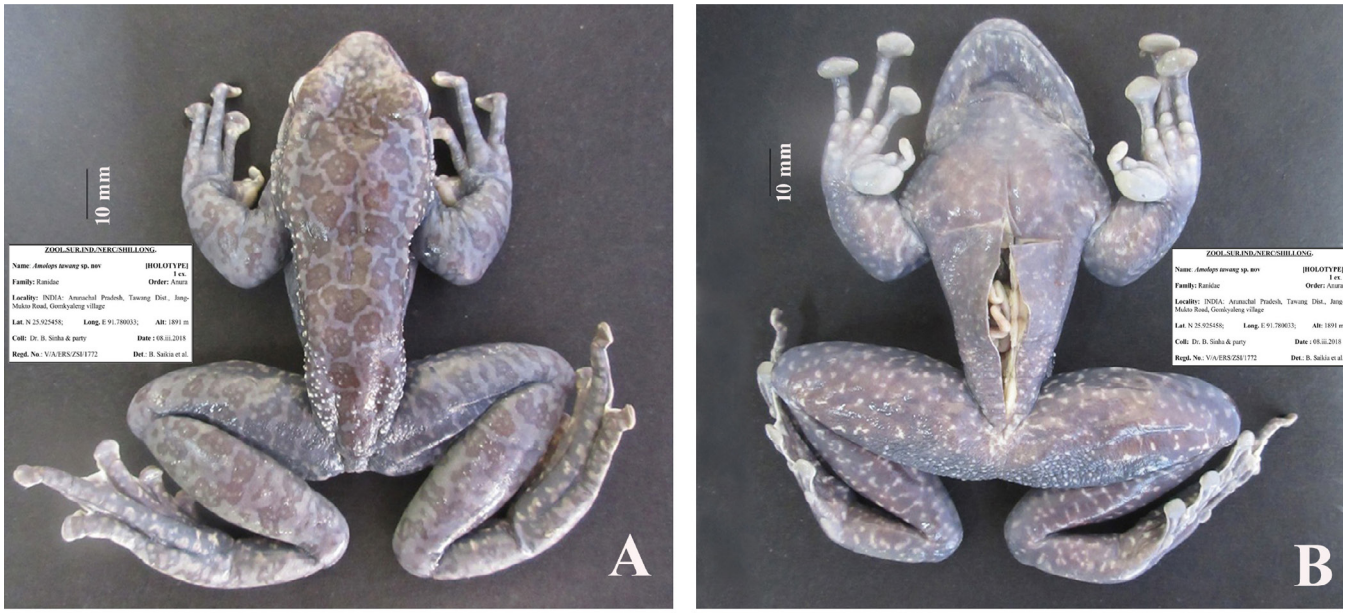

Figure 6. Holotype image of *Amolops tawang* **sp. nov.** in preserved condition (**A:** dorsal view; **B:** ventral view).

a pair of vomerine teeth situated between the choanae; tongue bilobed. The vocal sac faintly visible.

Arms meaty, forearm length shorter than the hand length; fingers free, tips ending in disk, finger I disk slightly dilated, all disks with circum-marginal grooves except finger I, relative length of fingers I<II<IV<III; sub-articular tubercles prominent, circular; prepollex oval.

Hindlimbs long and strong, tibia longer than both femur and foot (TiL>FOL>ShL); toes long, tips of all toes dilated into disks with circum-marginal grooves, toes completely webbed; sub-articular tubercles domed shaped; inner metatarsal tubercle oval shaped, outer absent.

The dorsal skin is smooth, slightly granular towards dorso-lateral sides; the supra-tympanic fold is strong; lateral and ventral skin is smooth.

Colouration of the Holotype: (*in life*) Dorsal color olive-green, spotted with large, irregular shaped dark-brown spots, brown spots enclosing a number of small olive-green dots; laterally same as dorsally; ventral color dark, speckled with lighter dots and dashes. Dorso-laterally granular along with white-tipped minute tubercles. Tibia banded; thighs mottled with dark brown and olive-green (Figure 5). *In preservative* same as in live condition, except that all the olive-green colours are faded (Figure 6).

Condition of the type: The type is in good condition. A ventral incision was made in the type specimen to extract liver tissue, which was used in the molecular study.

Natural history: The lone specimen of *A. tawang* **sp. nov**. was collected during the mid-day from a torrential hill stream with low water volume, which was characterised by large boulders. The specimen was resting under a boulder in a shallow trickle of water. A single specimen of *Nanorana liebigii* was also collected from the same habitat.

Distribution: Currently, this species is known only from its type locality in Tawang District, Arunachal Pradesh, India.

Comparisons: The new species is compared with the other species of *Viridimaculatus* species group.

From the Indian *Viridimaculatus* species group, *Amolops tawang* **sp. nov.** differs from *A. formosus* (in parentheses) in having adult male larger (vs. smaller), tympanum small, distinct and depressed (vs. about the size of finger III disk), inner-metatarsal tubercles distinct (vs. indistinct), circum-marginal groove on finger I absent (vs. present), outer metatarsal tubercle absent (vs. present), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. bright green with large dark spots), limbs with incomplete bands (vs. uniformly banded); from *A. himalayanus* (in parentheses) in having larger male SVL >82 mm (vs. smaller <74-75 mm), nostril equidistant (vs. nearer to eye), tympanum small, distinct and depressed (vs. slightly visible), visible sac faintly visible (vs. externally visible vocal sac present), tibia 2/3rd of SVL (vs. almost equal), tibio-tarsal articulation reached up to the snout (vs. beyond the tip of the snout), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. olive with darker spots); from *A. nidorbellus* (in parentheses) in having larger male SVL >82 mm (vs. smaller <77 mm), IUEUEW (vs. IUE>EUW), pineal ocellus distinct (vs. barely visible), vocal sac faintly visible (vs. externally visible vocal sacs absent), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. brown with small, irregular cobalt green spots), ventral color dark, speckled with lighter dots and dashes (vs. pale brown with scattered small, white spots); from *A. viridimaculatus* sensu stricto (in parentheses) in having larger male SVL >82 mm (vs. smaller <77 mm), head wider (vs. longer), tympanum distinct (vs. indistinct), outer metatarsal tubercle absent (vs. present), limbs not distinctly banded (vs. distinctly banded), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. maroon red with large green blotches); from *A. chanakya* **sp. nov.** (in parentheses) in having larger male SVL >82 mm (vs. smaller <77 mm), nostril equidistant (vs. nearer to the eye), IUE=UEW (vs. IUE<UEW), tympanum extremely depressed and small (vs. larger), TYD = ½TE (vs. TYD ≈ TE), external vocal sac faintly visible (vs. distinctly visible), tibio-tarsal articulation reaches up to snout (vs. nostril), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. dorsum dull brick-red, spotted with irregular cocoa-brown spots), ventral color dark, speckled with lighter dots and dashes (vs. ventral cocoa-brown).

From the *Viridimaculatus* species group found outside India, *Amolops tawang* **sp. nov.** differs from *A. beibengensis* (in parentheses) in having larger male SVL >82 mm (vs. <76 mm), head wider than long (vs. HL=HW), tibio-tarsal articulation reached up to the snout (vs. between nose and eye), vocal sac faintly visible (vs. absent), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. dorsum brown

with green spots); from *A. gyirongensis* (in parentheses) in having larger male SVL >82 mm (vs. <64 mm), tibio-tarsal articulation reached up to the snout (vs. nostril), vocal sac faintly visible (vs. absent); dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. bright green with dark brown irregular large spots); from *A. kaulbacki* (in parentheses) in having larger male SVL >82 mm (vs. up to 72 mm), IN>IUE=UEW (vs. IN>IUE>UEW), tibio-tarsal articulation reached up to the snout (vs. beyond snout), vocal sac faintly visible (vs. absent), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. green with black spots and marbling); from *A. longimanus* (in parentheses) in not having distinctive dorsolateral fold (vs. present), absence of parotid-like swelling above tympanum (vs. present); from *A. medogensis* (in parentheses) in having smaller male SVL of 82 mm (vs. 95 mm), vocal sac faintly visible (vs. absent), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. olive green with brown markings/dark brown with small yellow-green spots); from *A. pallasitatus* (in parentheses) in having tibio-tarsal articulation reached up to the snout (vs. posterior eye corner), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. yellow green with irregular dark brown blotches); from *A. splendissimus* (in parentheses) in having larger male SVL >82 mm (vs. 76 mm), IUE=UWD (vs. IUE<UEW), supra-tympanic fold strong (vs. poorly developed), vocal sac faintly visible (vs. absent), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. black-brown spangled thickly with bright yellow spots); from *A. wangyufani* (in parentheses) in having larger male SVL >82 mm (vs. <70 mm), tibio-tarsal articulation reached up to the snout (vs. beyond snout), dorsal color olive-green, spotted with large, irregular shaped dark-brown spots (vs. brown with sparse green patches).

Etymology: The species epithet is a toponym named after the district Tawang, from where the type was collected. Located in the westernmost part of Arunachal Pradesh, Tawang is renowned for Tawang Monastery, which is the largest in India as well as being the birthplace of the 6th Dalai Lama, Tsangyang Gyatso. The species epithet is treated as a noun in apposition to the generic name.

Suggested Common Name: We suggest **Tawang cascade frog** as a common English name and तवांग झरना मेंढक as a common Hindi name for this species.

Discussion

Jiang, *et al.,* (2021) revised the diagnostic characters of the *Viridimaculatus* species group where they have included 13 species of *Amolops* of which *A. caelumnoctis* has recently been placed under the synonymy of *A. splendissimus* by Zhang, *et al.,* (2021). Our proposed new species belong to the *Viridimaculatus* species group based on the similarities in morphology, however, with one morphological difference. Jiang, *et al.,* (2021) stated that the vocal sac is absent in the *Viridimaculatus* species group except *A. himalayanus*. Our proposed new species of *A. chanakya* **sp. nov**. with a distinct external vocal sac and *A. tawangensis* **sp. nov**. with a faint visible vocal sac, and along with *A. himalayanus,* prove to be the morphological exceptions within this species group.

A brief account on the occurrence of *A. viridimaculatus* sensu stricto was reported from Dzuna, Nagaland, India by Ao, *et al.,* (2003), while Saikia, *et al.,* (2022) have refuted the previous reports of *A. viridimaculatus/A. cf. viridimaculatus* from Arunachal Pradesh (Pawar and Birand, 2001; Athreya, 2006; Saikia and Das, 2017) which they suspected to be undescribed lineages of the *Viridimaculatus* species group.

In the distribution range of the *Amolops* a total of 73 species are described from the cascade waters of Nepal, China, Malaya, north and northeast India, but they are not completely represented on the phylogenetic tree (Figure 2). The moderate bootstrap values on the tree suggest the poor representation of the members of *Amolops* from its entire range of distribution. The species *Amolops chanakya* **sp. nov.** and *Amolops tawang* **sp. nov.** are described from the adjacent districts of Arunachal Pradesh which are adapted to higher elevation hill ranges. Species adaptation to the higher elevation mountain tips on the adjacent hill ranges separated by deep gap / pass are going to limit the dispersal of the species in question ending up in species isolation with limited distribution ranges. Moreover, despite a less genetic distance between these two populations of our proposed new species, they are isolated from each other by a huge mountain relief feature known as Sela Pass, which at an elevation of about 4200 m asl appears to form a formidable natural geographical barrier between these two type localities. The phylogenetic information on the tree (Figure 2)

and complexity in the geographical distribution range of *Amolops* suggests the possibilities of discovery and description of many more new species in the near future. Furthermore, phylogenetic studies suggest the recent speciation events (less genetic distance between the sister species) this could be due to the complex hill formation geological events in the Arunachal Pradesh hill ranges (Warren, *et al.,* 2014; Sarma, *et al.,* 2017).

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Appendix 1. GenBank accession numbers for mt 16S rRNA sequences used in the maximum-likelihood Phylogenetic analysis of cascade frogs of *Amolops* sps. (Saikia, *et al.,* 2022).

Sr. No	NCBI Accession no.	Species name used in the study	Collection locality	References
1	**ON025582**	***Amolops chankaya* sp. nov.**	**India: Arunachal Pradesh: West Kameng**	**This study**
2	**ON025581**	***Amolops tawang* sp. nov.**	**India: Arunachal Pradesh: Tawang**	**This Study**
3	MN953737.1	*A. viridimaculatus*	China: Pianma, Yunnan	Wu, *et al.,*(2020)
4	MN953736.1	*A. viridimaculatus*	China: Pianma, Yunnan	Wu, *et al.,*(2020)
5	MN953662.1	*A. beibengensis*	China: Medog, Tibet	Wu, *et al.,*(2020)
6	MN953663.1	*A. beibengensis*	China: Medog, Tibet	Wu, *et al.,*(2020)
7	MN953733.1	*Amolops* sps.	China: Pianma, Yunnan	Wu, *et al.,*(2020)
8	MN953734.1	*Amolops* sps.	China: Pingbian, Yunnan	Wu, *et al.,*(2020)
9	MN953735.1	*Amolops* sps.	China: Pingbian, Yunnan	Wu, *et al.,*(2020)
10	MN953731.1	*Amolops* sps.	China: Tengchong, Yunnan	Wu, *et al.,*(2020)
11	MN953732.1	*Amolops* sps.	China: Tengchong, Yunnan	Wu, *et al.,*(2020)
12	MN953738.1	*Amolops* sps.	China: Gongshan, Yunnan	Wu, *et al.,*(2020)
13	AB211480.1	*Amolops* sps.	China: Yunnan	Matsui, *et al.,* (2006); Khatiwada, *et al.,* (2020)
14	MN953711.1	*A. medogensis*	Medog, Tibet, China	Wu, *et al.,*(2020)
15	MN953710.1	*A. medogensis*	Medog, Tibet, China	Wu, *et al.,*(2020)
16	MK573813.1	*A. medogensis*	Xizang, China	Lyu, *et al.,* (2019)
17	MN953740.1	*A. wangyufani*	China: Zayü, Tibet	Wu, *et al.,*(2020)
18	MN953741.1	*A. wangyufani*	China: Zayü, Tibet	Wu, *et al.,* (2020)
19	MN953680.1	*A. granulosus*	China: Dayi, Sichuan	Wu, *et al.,* (2020)
20	MN953681.1	*A. granulosus*	China: Anxian, Sichuan	Wu, *et al.,* (2020)
21	MG991904.1	*A. tuberodepressus*	China:Yunnan	Khatiwada, *et al.,* (2020)
22	EF453743.1	*A. loloensis*	China: Xichang, Sichuan	Cai, *et al.,* (2007); Wu, *et al.,* (2020)
23	MN953757.1	*A. loloensis*	China: Xichang, Sichuan	Wu, *et al.,* (2020)
24	MN953705.1	*A. loloensis*	China: Yuexi, Sichuan	Wu, *et al.,* (2020)
25	MN953704.1	*A. loloensis*	China: Xichang, Sichuan	Wu, *et al.,*(2020)

26	AB211478.1	*A. loloensis*	China: Sichuan	Matsui. *et al.*. (2006); Khatiwada, *et al.,* (2020)
27	MN953756.1	*A. loloensis*	China: Xichang, Sichuan	Wu, *et al.,* (2020)
28	EF453741.1	*A. jinjiangensis*	China: Deqing, Yunnan	Cai, *et al.,* (2007); Wu, *et al.,* (2020)
29	MN953701.1	*A. jinjiangensis*	China: Chuxiong, Yunnan	Wu, *et al.,* (2020)
30	MN953700.1	*A. jinjiangensis*	China: Deqing, Yunnan	Wu, *et al.,* (2020)
31	MK604846.1	*A. shuichengicus*	China: Shuicheng County, Guizhou	Lyu, *et al.,* (2019)
32	MK604845.1	*A. shuichengicus*	China: Shuicheng County, Guizhou	Lyu, *et al.,* (2019)
33	MN953730.1	*A. tuberodepressus*	China: Jingdong, Yunnan	Wu, *et al.,*(2020)
34	MN953729.1	*A. tuberodepressus*	China: Jingdong, Yunnan	Wu, *et al.,*(2020)
35	MN953765.1	*A. mantzorum*	China: Kangding, Sichuan	Wu, *et al.,*(2020)
36	EF453742.1	*A. mantzorum*	China	Unpublished
37	AB211479.1	*A. mantzorum*	China: Sichuan	Matsui, *et al.,* (2006); Khatiwada, *et al.,* (2020)
38	MN953706.1	*A. mantzorum*	China: Wolong, Sichuan	Wu, *et al.,*(2020)
39	MN953707.1	*A. mantzorum*	China: Dayi, Sichuan	Wu, *et al.,*(2020)
40	MN953764.1	*A. mantzorum*	China: Kangding, Sichuan	Wu, *et al.,*(2020)
41	MK604877.1	*A. chayuensis*	China: Xizang	Lyu, *et al.,* (2019); Khatiwada, *et al.,* (2020)
42	MN953667.1	*A. chayuensis*	China: Baxoi, Tibet	Wu, *et al.,*(2020)
43	MN953666.1	*A. chayuensis*	China: Baxoi, Tibet	Wu, *et al.,*(2020)
44	MN953714.1	*Amolops* sps.	Nepal: Maimajhuwa, Ilam	Wu, *et al.,*(2020)
45	MN953712.1	*Amolops* sps.	Nepal: Rakshe Village, Mechi	Wu, *et al.,*(2020)
46	MN953713.1	*Amolops* sps.	Nepal: Mabu, Ilam	Wu, *et al.,*(2020)
47	FJ417145.1	*A. cucae*	Vietnam: Van Ban, Lao Cai	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)
48	FJ417144.1	*A. cucae*	Vietnam: Van Ban, Lao Cai	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)
49	FJ417129.1	*A. wenshanensis*	China: Jinxiu, Guangxi	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)
50	MN953725.1	*A. wenshanensis*	China: Xichou, Yunnan	Yuan, *et al.,* 2018; Wu, *et al.,*(2020)
51	MN953724.1	*A. wenshanensis*	China: Xichou, Yunnan	Yuan, *et al.,* 2018; Wu, *et al.,*(2020)
52	FJ417142.1	*A. compotrix*	Vietnam: Dak Glei, Kon Tum	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)
53	FJ417141.1	*A. compotrix*	Laos: Nakai	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)
54	MN953739.1	*A. vitreus*	Laos: Phongsaly, Phou Dendin National Biodiversity Conservation Area	Wu, *et al.,*(2020)
55	FJ417164.1	*A. vitreus*	Laos: Phongsaly, Phongsaly	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)

56	MN953678.1	*A. daorum*	China: Jingdong, Yunnan	Wu, *et al.*,(2020)
57	MN953679.1	*A. daorum*	China: Jingdong, Yunnan	Wu, *et al.*,(2020)
58	MN953661.1	*A. archotaphus*	Thailand: Doi Inthanon, Chiang Mai	Wu, *et al.*,(2020)
59	MN953660.1	*A. archotaphus*	Thailand: Doi Inthanon, Chiang Mai	Wu, *et al.*,(2020)
60	MN953659.1	*A. archotaphus*	Thailand: Amphoe Chom Thong, Chiang Mai	Wu, *et al.*,(2020)
61	FJ417158.1	*A. akhaorum*	Laos: Vieng Phou Kha, Luang Namtha	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
62	FJ417159.1	*A. akhaorum*	Laos: Vieng Phou Kha, Luang Namtha	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
63	MK501808.1	*A. mengdingensis*	China: Mengding, Yunnan	Yu, *et al.,* 2019
64	MK501809.1	*A. mengdingensis*	China: Mengding, Yunnan	Yu, *et al.,* 2019
65	MK501810.1	*A. mengdingensis*	China: Mengding, Yunnan	Yu, *et al.,* 2019
66	FJ417147.2	*Amolops* sps.	Laos: Vieng Tong, Huaphahn	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
67	FJ417148.2	*Amolops* sps.	Laos: Vieng Tong, Huaphahn	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
68	FJ417153.2	*A. iriodes*	Vietnam: Vi Xuyen, Ha Giang	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
69	FJ417152.2	*A. iriodes*	Vietnam: Vi Xuyen, Ha Giang	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
70	FJ417151.2	*A. mengyangenesis*	Vietnam: Sa Pa, Lao Cai	Stuart, *et al.,* (2010); Patel, *et al.,* (2021)
71	KR827703.1	*A. mengyangenesis*	Vietnam: Sa Pa, Lao Cai	Grosjean, *et al.,* (2015); Patel, *et al.,* (2021)
72	KR827704.1	*A. mengyangenesis*	Vietnam: Sa Pa, Lao Cai	Grosjean, *et al.,* (2015); Patel, *et al.,* (2021)
73	MZ229774.1	*A. kohimaensis*	India: Nagaland	Patel, *et al.,* (2021)
74	MN953657.1	*Amolops* sps.	China: Medog, Tibet	Wu, *et al.*,(2020)
75	MZ229772.1	*A. adicola*	India: Arunachal Pradesh	Patel, *et al.,* (2021)
76	OK138593.1	*A. adicola*	India: Arunachal Pradesh: Upper Subansiri	Saikia, *et al.,* (2022)
77	MZ229773.1	*A. monticola*	India: South Sikkim	Patel, *et al.,* (2021)
78	MT636754.1	*A. aniqiaoensis*	India: Arunachal Pradesh: Upper Subansiri	Saikia, *et al.,* (2022)
79	MT636755.1	*A. aniqiaoensis*	India: Arunachal Pradesh: Upper Subansiri	Saikia, *et al.,* (2022)
80	MN953658.1	*A. aniqiaoensis*	China: Tibet	Wu, *et al.*,(2020)
81	MN953655.1	*A. aniqiaoensis*	China: Medog, Tibet	Wu, *et al.*,(2020)
82	MN953656.1	*A. aniqiaoensis*	China: Medog, Tibet	Wu, *et al.*,(2020)
83	FJ417127.2	*A. bellulus*	China: Teng Chong Co., Yunnan	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
84	MN953664.1	*A. bellulus*	China: Teng Chong Co., Yunnan	Wu, *et al.*,(2020)
85	MN953665.1	*A. bellulus*	China: Teng Chong Co., Yunnan	Wu, *et al.*,(2020)

86	MN953719.1	*A. nyingchiensis*	China: Mainling, Tibet	Wu, *et al.*,(2020)
87	MN953717.1	*A. nyingchiensis*	China: Mainling, Tibet	Wu, *et al.*,(2020)
88	MN953718.1	*A. nyingchiensis*	China: Medog	Wu, *et al.*,(2020)
89	MN953716.1	*A. nyingchiensis*	China: Mainling, Tibet	Wu, *et al.*,(2020)
90	MN953715.1	*A. nyingchiensis*	China: Mainling, Tibet	Wu, *et al.*,(2020)
91	MN953699.1	*A. deng*	China: Medog, Tibet	Wu, *et al.*,(2020)
92	MN953698.1	*A. deng*	China: Zayü, Tibet	Wu, *et al.*,(2020)
93	MN953697.1	*A. deng*	China: Zayü, Tibet	Wu, *et al.*,(2020)
94	MN953695.1	*A. deng*	China: Zayü, Tibet	Wu, *et al.*,(2020)
95	MN953696.1	*A. deng*	China: Zayü, Tibet	Wu, *et al.*,(2020)
96	FJ417126.2	*Amolops* sps.	China: Teng Chong Co., Yunnan	Stuart, *et al.,* (2010); Wu, *et al.*,(2020)
97	MN953668.1	*A. chaochin*	China: Sichuan: Anxian	Wu, *et al.*,(2020); Jiang, *et al.,* (2021)
98	MN953669.1	*A. chaochin*	China: Sichuan: Anxian	Wu, *et al.*,(2020); Jiang, *et al.,* (2021)
99	MN953766.1	*A. chaochin*	China: Gansu	Wu, *et al.*,(2020)
100	AB211477.1	*A. chaochin*	China: Sichuan: Mt. Emei	Wu, *et al.*,(2020); Jiang, *et al.,* (2021)
101	KU840605.1	*A. chaochin*	China: Sichuan: Mt.Qingcheng	Wu, *et al.*,(2020); Jiang, *et al.,* (2021)
102	MN953762.1	*A. chunganensis*	China: Chengkou, Chongqing	Wu, *et al.*,(2020)
103	MN953670.1	*A. chunganensis*	China: Chengkou, Chongqing	Wu, *et al.*,(2020)
104	MG991886.1	*A. chunganensis*	China: Mt. Jinggang, Jiangxi	Lyu, *et al.,* (2018)
105	KX507310.1	*A. chunganensis*	China: Mt. Wugong, Anfu, Jiangxi	Sung, *et al.,* (2016)
106	MN953671.1	*A. chunganensis*	China: Fangxian, Hubei	Wu, *et al.*,(2020)
107	MN953685.1	*A. gyirongensis*	China: Gyirong, Tibet	Wu, *et al.*,(2020)
108	MN953683.1	*A. gyirongensis*	China: Gyirong, Tibet	Wu, *et al.*,(2020)
109	MN953684.1	*A. gyirongensis*	China: Gyirong, Tibet	Wu, *et al.*,(2020)
110	MN953686.1	*A. gyirongensis*	China: Gyirong, Tibet	Wu, *et al.*,(2020)
111	MN953682.1	*A. gyirongensis*	China: Gyirong, Tibet	Wu, *et al.*,(2020)
112	MT124524.1	*A. nepalicus*	Nepal: Dobhan, Sankhuwasabha	Khatiwada, *et al.,* (2020)
113	MT124524.1	*A. nepalicus*	Nepal: Dobhan, Sankhuwasabha	Khatiwada, *et al.,* (2020)
114	MT124522.1	*A. nepalicus*	Nepal: Dobhan, Sankhuwasabha	Khatiwada, *et al.,* (2020)
115	MT124523.1	*A. nepalicus*	Nepal: Dobhan, Sankhuwasabha	Khatiwada, *et al.,* (2020)
116	AB211481.1	*A. lifanensis*	China: Sichuan	Matsui, *et al.,* 2006; Khatiwada, *et al.,* (2020)
117	MN953702.1	*A. lifanensis*	China: Maoxian, Sichuan	Wu, *et al.*,(2020)
118	MN953703.1	*A. lifanensis*	China: Maoxian, Sichuan	Wu, *et al.*,(2020)
119	AB211482.1	*A. lifanensis*	China: Sichuan	Matsui, *et al.,* (2006); Khatiwada, *et al.,* (2020)
120	MW794278.1	*Amolops* sps.	India: Arunachal Pradesh, Sessa Wildlife Sanctuary	Unpublished

121	MW794279.1	*Amolops* sps.	India: Arunachal Pradesh, Sessa Wildlife Sanctuary	Unpublished
122	MW794280.1	*Amolops* sps.	India: Arunachal Pradesh, Sessa Wildlife Sanctuary	Unpublished
123	MW794281.1	*Amolops* sps.	India: Arunachal Pradesh, Sessa Wildlife Sanctuary	Unpublished
124	MW794282.1	*Amolops* sps.	India: Arunachal Pradesh, Sessa Wildlife Sanctuary	Unpublished
125	MT124518.1	*A. formosus*	Nepal: Kimathanka, Sankhuwasabha	Khatiwada, *et al.,* (2020)
126	MN953750.1	*A. formosus*	Nepal: Mabu, Ilam	Wu, *et al.,*(2020); Patel, *et al.,* (2021)
127	MT124519.1	*A. formosus*	Nepal: Lamatar, Taplejung	Khatiwada, *et al.,* (2020)
128	MT124517.1	*A. formosus*	Nepal: Kimathanka, Sankhuwasabha	Khatiwada, *et al.,* (2020)
129	OK138592.1	*A. gerbillus*	India: Arunachal Pradesh, Kamle	Unpublished
130	MN953746.1	*A. yarlungzangbo*	China: Medog, Tibet	Wu, *et al.,*(2020)
131	MN953747.1	*A. yarlungzangbo*	China: Medog, Tibet	Wu, *et al.,*(2020)
132	MN953744.1	*A. yarlungzangbo*	China: Medog, Tibet	Wu, *et al.,*(2020)
133	MN953745.1	*A. yarlungzangbo*	China: Medog, Tibet	Wu, *et al.,*(2020)
134	MT124512.1	*A. mahabharatensis*	Nepal: Pokhara, Kaski district	Khatiwada, *et al.,* (2020)
135	MT124511.1	*A. mahabharatensis*	Nepal: Pokhara, Kaski district	Khatiwada, *et al.,* (2020)
136	MT124513.1	*A. mahabharatensis*	Nepal: Barahakshetra, Sunsari district	Khatiwada, *et al.,* (2020)
137	MT124507.1	*A. mahabharatensis*	Nepal: Hattibang, Chitwan district	Khatiwada, *et al.,* (2020)
138	MT124509.1	*A. mahabharatensis*	Nepal: Hattibang, Chitwan district	Khatiwada, *et al.,* (2020)
139	MT124514.1	*A. mahabharatensis*	Nepal: Barahakshetra, Sunsari district	Khatiwada, *et al.,* (2020)
140	MT124508.1	*A. mahabharatensis*	Nepal: Hattibang, Chitwan district	Khatiwada, *et al.,* (2020)
141	MT124510.1	*A. mahabharatensis*	Nepal: Hattibang, Chitwan district	Khatiwada, *et al.,* (2020)
142	MT124516.1	*A. mahabharatensis*	Nepal: Latinath, Darchula district	Khatiwada, *et al.,* (2020)
143	MT124515.1	*A. mahabharatensis*	Nepal: Latinath, Darchula district	Khatiwada, *et al.,* (2020)
144	MN953722.1	*A. panhai*	Myanmar: Pakchan Reserve Forest, Kawthoung, Tanintharyi	Wu, *et al.,*(2020)
145	JF794451.1	*A. panhai*	Myanmar: Tanintharyi	Dever *et al.* (2012); Khatiwada, *et al.,* (2020)
146	AB211488.1	*A. panhai*	Thailand: Phetchaburi	Matsui *et al.* (2006); Khatiwada, *et al.,* (2020)
147	MN953720.1	*A. panhai*	Thailand: Huay Yang National Park, Prachuap Khiri Khan	Wu, *et al.,*(2020)
148	MN953721.1	*A. panhai*	Thailand: Ngao Falls National Park, Ranong	Wu, *et al.,*(2020)
149	MN953708.1	*A. marmoratus*	Thailand: Huai Hea, Chiang Mai	Wu, *et al.,*(2020)
150	MN953709.1	*A. marmoratus*	Thailand: Wachiratarn Falls, Amphoe Chom Thong, Chiangmai	Wu, *et al.,*(2020)

151	JF794453.1	*A. marmoratus*	Myanmar: Mon	Dever, *et al.,* (2012); Khatiwada, *et al.,* (2020)
152	JF794454.1	*A. marmoratus*	Myanmar: Mon	Dever, *et al.,* (2012); Khatiwada, *et al.,* (2020)
153	MN953694.1	*A. indoburmanensis*	Myanmar: Upper Bee Hoe village, Mindat, Chin	Wu, *et al.,*(2020)
154	MN953692.1	*A. indoburmanensis*	Myanmar: Baw village, Chin	Wu, *et al.,*(2020)
155	MN519705.1	*A. indoburmanensis*	India: Mizoram, Murlen National Park	Saikia, *et al.,* (2022)
156	MN953693.1	*A. indoburmanensis*	Myanmar: Haka Township, Chin	Wu, *et al.,*(2020)
157	JF794460.1	*A. indoburmanensis*	Myanmar: Rakhine	Dever, *et al.,* (2012); Khatiwada, *et al.,* (2020)
158	JF794431.1	*A. afganus*	Myanmar: Kachin	Dever, *et al.,* (2012); Khatiwada, *et al.,* (2020)
159	MN953773.1	*A. afghanus*	Myanmar: Indawgyi Lake Wildlife Sanctuary, Kachin	Wu, *et al.,*(2020)
160	MN953774.1	*A. afghanus*	Myanmar: Myitkyina	Wu, *et al.,*(2020)
161	MN953654.1	*A. afghanus*	China: Husa, Yunnan	Wu, *et al.,*(2020)
162	MN953690.1	*A. hongkongensis*	China: Hong Kong	Wu, *et al.,*(2020)
163	KX507317.1	*A. hongkongensis*	China: Hong Kong	Sung, *et al.,* (2016); Khatiwada, *et al.,* (2020)
164	MN953691.1	*A. hongkongensis*	China: Hong Kong	Wu, *et al.,*(2020)
165	MN953689.1	*A. hongkongensis*	China: Hong Kong	Wu, *et al.,*(2020)
166	KX507306.1	*A. daiyunensis*	China: Mt. Daiyu, Fujian	Sung, *et al.,* (2016); Khatiwada, *et al.,* (2020)
167	MN953676.1	*A. daiyunensis*	China: Daiyunshan, Fujian	Wu, *et al.,*(2020)
168	MN953675.1	*A. daiyunensis*	China: Daiyunshan, Fujian	Wu, *et al.,*(2020)
169	MN953677.1	*A. daiyunensis*	China: Daiyunshan, Fujian	Wu, *et al.,*(2020)
170	MK263277.1	*A. yunkaiensis*	China: Ehuangzhang Nature Reserve, Guangdong	Lyu, *et al.,* (2018, 2019)
171	MK263271.1	*A. yunkaiensis*	China: Yunkaishan Nature Reserve, Guangdong	Lyu, *et al.,* (2018, 2019)
172	MN953763.1	*A. sinensis*	China: Gongcheng, Guangxi	Wu, *et al.,*(2020)
173	MK263262.1	*A. sinensis*	China: Guangdong	Lyu, *et al.,* (2019); Khatiwada, *et al.,* (2020)
174	MN953775.1	*A. sinensis*	China: Guidong, Hunan	Wu, *et al.,*(2020)
175	MN953748.1	*A. sinensis*	China: Mao'er Shan, Guangxi	Wu, *et al.,*(2020)
176	MN953749.1	*A. sinensis*	China: Mao'er Shan, Guangxi	Wu, *et al.,*(2020)
177	KX507312.1	*A. albispinus*	China: Yunkaienshan	Sung, *et al.,* (2016); Khatiwada, *et al.,* (2020)
178	MK263248.1	*A. albispinus*	China: Mt. Wutong, Guangdong	Sung, *et al.,* (2016); Lyu, *et al.,* (2019)
179	MK263249.1	*A. albispinus*	China: Mt. Wutong, Guangdong	Sung, *et al.,* (2016); Lyu, *et al.,* (2019)

180	MK263290.1	*A. yatseni*	China: Zhongshan City, Guangdong	Lyu, *et al.,* (2019)
181	MK263250.1	*A. yatseni*	China: Shangchuan Island, Guangdong	Lyu, *et al.,* (2019)
182	MN953723.1	*A. yatseni*	Vietnam: Sa Pa, Lao Cai	Wu, *et al.,*(2020)
183	MN953758.1	*A. yatseni*	China: Jingxi, Guangxi	Wu, *et al.,*(2020)
184	DQ204486.1	*A. ricketti*	China: Shanghang, Fujian	Orlov, *et al.,* (2006); Khatiwada, *et al.,* (2020)
185	MN953743.1	*A. rickettii*	China: Wuyishan, Fujian	Wu, *et al.,*(2020)
186	MN953759.1	*A. rickettii*	China: Shicheng, Jiangxi	Wu, *et al.,*(2020)
187	MN953760.1	*A. wuyiensis*	China: Wencheng, Zhejiang	Wu, *et al.,*(2020)
188	MN953761.1	*A. wuyiensis*	China: Yiwu, Zhejiang	Wu, *et al.,*(2020)
189	MN953742.1	*A. wuyiensis*	China: Wuyishan, Fujian	Wu, *et al.,*(2020)
190	KX507304.1	*A. wuyiensis*	China: Fujian	Sung, *et al.,* (2016); Khatiwada, *et al.,* (2020)
191	MN953727.1	*A. spinapectoralis*	Vietnam: Kon Ka Kinh, Gia Lai	Wu, *et al.,*(2020)
192	MN953770.1	*A. spinapectoralis*	Vietnam: Tram Lap, Gia Lai	Wu, *et al.,*(2020)
193	MN953726.1	*A. spinapectoralis*	Vietnam: Ngoc Linh vicinity, Kon Tum	Wu, *et al.,*(2020)
194	MN953771.1	*A. spinapectoralis*	Vietnam: Central Highland, Ngok Linh, Kon Tum	Wu, *et al.,*(2020)
195	AF206456.1	*A. spinapectoralis*	Vietnam: Gia Lai	Chen, *et al.,* (2005); Khatiwada, *et al.,* (2020)
196	MN953768.1	*A. spinapectoralis*	Vietnam: Bana resort, Da Nang	Wu, *et al.,*(2020)
197	MN953769.1	*A. spinapectoralis*	Vietnam: Phong Dien Nature Reserve, Phong Dien, Thua Thien Hue	Wu, *et al.,*(2020)
198	MN953772.1	*A. spinapectoralis*	Vietnam: Phong Dien Nature Reserve, Phong Dien, Thua Thien Hue	Wu, *et al.,*(2020)
199	MN953728.1	*A. torrentis*	China: Diao Luo Shan forest Park, Lingshui, Hainan	Wu, *et al.,*(2020)
200	EF453744.1	*A. torrentis*	China: Hainan	Wu, *et al.,*(2020)
201	MN953687.1	*A. hainanensis*	China: Wuzhishan, Hainan	Wu, *et al.,*(2020)
202	MN953688.1	*A. hainanensis*	China: Wuzhishan, Hainan	Wu, *et al.,*(2020)
203	KX507320.1	*A. hainanensis*	China: Hainan	Sung, *et al.,* (2016); Khatiwada, *et al.,* (2020)
204	MN953674.1	*A. cremnobatus*	Thailand: Doi Phuka, Chom Poo Phuka nature trail, Nan	Wu, *et al.,*(2020)
205	DQ204477.1	*A. cremnobatus*	Vietnam: Khe Moi	Orlov *et al.* (2006); Khatiwada, *et al.,* (2020)
206	FJ417143.1	*A. cremnobatus*	Laos: Kasi, Vientiane	Stuart, *et al.,* (2010); Wu, *et al.,*(2020)
207	MN953673.1	*A. cremnobatus*	Vietnam: Puhu National Reserve, Thanh Hoa	Wu, *et al.,*(2020)

208	MN953672.1	*A. cremnobatus*	Vietnam: Puhu National Reserve, Thanh Hoa	Wu, *et al.*,(2020)
209	MF061741.1	*A. larutensis*	Malaysia: Gunung Bubu, Perak	Unpublished
210	MF061749.1	*A. larutensis*	Malaysia: Bukit Larut, Perak	Unpublished
211	MF061745.1	*A. australis*	Malaysia: Endau-Rompin, Johor (Peta)	Unpublished
212	MF061721.1	*A. gerutu*	Malaysia: Gunung Tebu, Terengganu	Unpublished
213	MN953755.1	*Odorrana jingdongensis*	China: Jingdong, Yunnan	Wu, *et al.*,(2020)
214	MN953752.1	*Huia cavitympanum*	Malaysia: Marak Parak, S. Tahobang, Kota Marudu, Sabah	Wu, *et al.*,(2020)
215	MN953753.1	*Rana jiemuxiensis*	China: Jiemuxi, Hunan	Wu, *et al.*,(2020)
216	MN953751.1	*Babina hainanensis*	China: Lingshui, Diao Luo Shan Forest Park, Hainan	Wu, *et al.*,(2020)